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# Biodiversity, Ecosystem Function and the Pollination Ecology of Urban Gardens in Dayton, Ohio

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Abstract

Urban agriculture is an ancient concept that is gaining momentum in the United States in connection with urban renewal projects and efforts to mediate urban food deserts. These agriculture efforts represent a potential habitat for pollinator communities within the urban hardscape. Pollinator communities are threatened by urban landscape transformation, and bee species, in particular, are in a state of global decline due to various stressors. Urban agriculture has the potential to sustain both human and ecological communities, and the pollinators that visit gardens may provide pollination to plant species in the surrounding area. We investigated the influence of urban land use on pollinator populations in urban Dayton to (a) quantify pollinators visiting urban gardens and (b) compare pollinator frequency and occurrences among urban gardens, vacant lots (abandoned with no management) and manicured lawns. Three sites were chosen around the Dayton area, an urban garden, a lawn, and a vacant lot. Phytometers and a modified Pollard walk were used to monitor the frequency of pollination within the sites. We discovered that the amount of pollinator frequency increased with the flora diversity of the lots. With the manicured lawn having the fewest pollinator visits and the managed urban garden having the most pollinator visit. We saw a relationship between human landscaping and the pollinator communities. From this data we have a better understanding of the effect of the urban landscape on pollinators that will lead to a better use of vacant lots and urban spaces within the city of Dayton.

UNIVERSITY of DAYTON

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**General Audience Abstract**

As the world is increasingly urbanized, humans are suffering myriad negative effects of disconnect from nature, and ecological communities are forced into smaller and smaller spaces. Heavy urbanization also has the effect of limiting access to fresh, healthy food for people living in those areas. A popular feature of urban revitalization is the implementation of urban agriculture as a way to increase food justice and bring together communities in low income areas. Urban agriculture, while being around for centuries, has become increasingly popular in the last few decades within the United States. Many psychological and socioeconomic studies have been conducted showing the positive effects of urban agriculture upon human communities; however, these agricultural plots are also miniature patches of potential habitat for some wildlife species. Pollinators, in particular, benefit from the abundance of flowers while also providing a key step for fruit production. The current threat of urbanization and disease has caused pollinator populations to decline, a threat not only to biodiversity but also the agriculture industry. Vacant lots within cities have the most potential to be transformed into these pollinator "novel ecosystems" as restoration does not have to compete with standing infrastructure on the property.

Our research focused on (a) comparing pollinator frequency and occurrences in an urban garden to that of a typical urban vacant and a typical managed lawn. Our hypotheses were that (a) due to the inherent ecological differences among the three land use types there would be variation in pollination visits and (b) there would be a positive correlation as between pollinator frequency and ecological complexity of the spaces such that those sites with more flowering plants would be favorable habitat for pollinators. The

findings from this research proved that there is a relationship between human planting practices and pollinator communities. The urban garden had the highest frequency of pollinators, both belonging to the order hymenoptera and all other pollinators, found during our observation period. This increases our knowledge of pollinator behaviors and encourages individuals to better plan their use of vacant lots to increase pollinator levels. This research project also created relationships within the Dayton community and the University of Dayton as well as established a new vein of ecological research at the University.

## Background

Urbanization is a global phenomenon in which various habitats are transformed for human use. The ecology of urbanized landscapes is radically altered as surfaces are made impermeable (Montgomery 2008), soil chemistry is altered, heat islands are formed (Grimm 2008), and species are lost (Czech 2004; Montgomery 2008). Urban development has increased rapidly since the onset of the industrial and agricultural revolutions (Lawson 2005). For instance, in the early 1900s 10% of the human population lived in urban areas and the UN predicts that by 2060 66% of the human population will reside within urban areas (Grimm 2008; UN 2013). Urbanization is known to have substantial negative effects on species diversity and carbon pools at a global scale (Foley 2005; Seto et al. 2011). Transforming these urban areas to increase their habitability for humans and to enhance ecological vitality has become a primary objective for urban planning and restoration ecology. An array of positive economic, psychological and social effects of urban gardening have been noted (Lawson 2005;Foley

2005;Amar-Klemsua 2000) and urban gardens also serve as potential microhabitats within the urban matrix (Armar-Klemsau 2000; Lowenstein et al. 2014). This revitalization also plays a role in creating greenspace and resources for pollinators. Envisioning even heavily impacted green spaces in urbanized areas as “novel ecosystems” has been viewed as a promising revolution in restoration ecology (Hobbs 2006) and urban gardens may act as “novel” ecosystems from the perspective of pollinators (Klein et al. 2007, Delaplane & Mayer 2000; Lowenstein et al. 2014).

The insects belonging to the order of hymenoptera, in particular the super family apoidea which encompass all species of bees, are important pollinators which are increasingly threatened with multiple stressors (Kremmel 2002). Bee pollination is a virtually irreplaceable ecosystem service to human agricultural endeavors (Klein et al 2007). In recent times there has been a decline in bee communities in both wild and managed communities resulting in significant losses of pollination services (Delaplane & Mayer 2000; Klein et al. 2007; Gallai et al. 2007). This decline has been linked to habitat destruction and fragmentation (Kremen et al.2002; Rathcke & Jules 1994; National Research Council 2007). Studies have shown local fauna and landscape can play a role in determining pollinator visits (Klein 2005) and evidence exists suggesting the decline of pollinators is associated with a decline of insect-pollinated plants (Biesmeijer et al. 2006). Urban gardens both rely upon, and provide habitat and resources for, bees; there have been few attempts to study bee population dynamics and urban agriculture thus making it an exciting field to be studying.

Research in urban environments has demonstrated a positive correlation between greenspace composition and pollinator frequency (Tonietto 2011, Lowenstein 2014).

Tonietto (2011) compared urban “green roofs,” natural prairies and traditional green-space parks and found a high correlation between bee and plant community composition. Indeed, the more diverse the plant community the greater benefit to bees (Tonietto 2011). A separate study set in Chicago (USA) found that pollination services in different socioeconomic neighborhoods differ as the human population density, proportion of surface concrete, and availability of floral resources change (Lowenstein 2014). Important environmental factors for bee richness and abundance were a high diversity of flowering plants, amount of grass or herbaceous cover and solar radiation within the areas of neighborhood (Lowenstein 2014). This study also reported that the relationship between human density and bee abundance can be positive as humans often have a direct positive effect upon floral resource availability (Lowenstein 2014).

The city of Dayton (Ohio, USA) is characteristic of many “post-industrial” cities in the Midwestern USA in that robust population growth and development has been followed by human population decline. In fact, within the past few decades the population of Dayton has been roughly halved from 262,322 in the 1960s to 141,527 in 2010, the most recent census (Census.gov). This human population dynamic has led to a city with a multitude of vacant lots. Dayton serves as a good model system as there has been a recent surge of urban renewal and urban agriculture projects that coincided with our research to compare different ways vacant lots could be refurbished. By comparing our three sites- standard (managed lawn), an abandoned lot, and a lot that had been transformed into an urban garden site, we will have a better understanding of pollinator and urban landscapes relationship.

The objectives of this project were to test the hypothesis that ($H_1$) the ecological makeup of the surrounding environment would have an effect on the frequency and types of pollinators that visit and ($H_2$) that a positive correlation exists between pollinator frequency and the level of management of the vacant spaces with higher diversity garden sites exceeding both managed lawn and a standard vacant lot.

## Methods

### *Site Selection*

The experimental design was created using three sites near Dayton, Ohio. The first site was located at an urban agriculture plot owned by Mission of Mary Farm on Hawker street within the Twin Towers neighborhood of Dayton. This site will be referred to as the "urban garden" throughout the rest of this paper. This site was chosen from multiple urban agriculture sites as it held vegetables with flowers that bloomed throughout fall. The second site was a vacant lot on Nassau street recently acquired by the University of Dayton within the Twin Towers Neighborhood of Dayton. This site will be referred to as the vacant lot throughout the rest of the paper. The vacant lot had not been mowed throughout the summer and at the time of data collection had an overgrowth of clover (*Trifolium*) and various grasses. This site represents a typical "abandoned lot" in an urban setting. The last site chosen was Village South Park located in Centerville, a suburb of Dayton (managed by the Centerville-Washington Township park system). This site was a large mowed lawn that served as a quasi-control and represents a land-use practice that is typical in urban and suburban areas. Throughout the rest of the paper this site will be referred to as "the lawn."

*Sampling*

Sampling was conducted using two complementary observational methodologies: (a) observation of phytometers and (b) modified pollard walks. Sampling was conducted during similar weather patterns and temperatures throughout September and October at midday. The order in which sites were visited was different for each consequent visit.

*Phytometers*

Phytometers have been shown to serve as a way to quantify pollination occurrences at a site (Pollard 1977). Phytometers were chosen based upon bloom times and observed pollinator attraction. The chosen plants were Autumn Joy Sedum, *Sedum telephium 'Autumn Joy'*, and Black Adder Hyssop, *Agastache 'Black Adder'* (Figure 2). In addition to bloom times occurring in the data collection time frame, we also choose plants that would tolerate direct sunlight for the full day as none of the sites had shade. Four plants, two of each species, were placed at the sites. One set of plants were placed at a chosen 'edge' of the site while the remaining set was placed at the 'center' or in the case of the urban agriculture site, placed amongst the agriculture rows. The 'edge' plants were a minimum of 3 meters away from sidewalks and roads to ensure that area around the phytometers where consistent with the site flora. Each plant was transferred to a black plastic pot and had the same soil to ensure no ground contamination affected results. Each set was also surrounded with mulch to deter vandalism and combat overheating of the pot. During data collection each set of plants were observed for 10 minutes and then watered. Hymenoptera, Lepidoptera, and other pollinators were recorded. Some data points for Hawker are missing as edge set plants were stolen twice (dates of no plants) and Village South Park has only two data points as it was acquired after an original 3rd site was no longer useable half-way through data collection.

*Pollard Walk*

A walking sample was collected for each site based upon methods of a Pollard walk (Pollard 1977). During the walk hymenoptera and lepidoptera that were observed were counted as well as flies that were observed to be on flowers (Figure 3). The same path was used for each date of collection and was timed to be 15 minutes. The vacant lawn and lawn were larger sites with a homogenous landscape compared to the urban garden site and thus had similar walk paths. The walking path for homogenous landscapes was a large square, 30 meters by 30 meters, with two of the edges of the box being the edge and center set of phytometers. The urban garden pollard walk path involved walking between the rows of urban agriculture and a path that led to the edge of the lot site. A representation of these sampling paths can be found within Figure 1.

*Analysis*

Frequency of pollinator visits where found by taking the average of the combination of phytometer and pollard walk data. All calculations and graphs were made using Microsoft excel.

## Results

The categories for pollinators were broken down into the class hymenoptera, made up of bees and wasps, and 'other' pollinators which were made up of lepidoptera, on flowers and traveling, and diptera, only if on flowers. We discovered a difference in visiting pollinators among our research sites. The urban garden site had the largest number of hymenoptera and other pollinators with an average visit of 11.4 and 24.4 insects, respectively, per data collection (Figure 3).

We found differences between pollinator count during the pollard walk and during the observations of phytometers (Figure 4 and 5). The urban garden site again had the greatest amount of pollinator visits across both methods for hymenoptera and pollinators classified as others. Phytometer and pollard walk counts were 6 and 5.4 respectively for pollinators per observation at the urban garden. The lawn had the lowest observation of hymenoptera with 3.5 for phytometer visits and 0 for the pollard walk. We found similar percentages of hymenoptera across two of our sites (Figure 6). The urban garden, lawn, and vacant lot had differing amounts of pollinator visits but proportionally had similar hymenoptera compositions of the community.

## Discussion

The impact of urbanization upon local ecosystems will continue to grow in the future. Current cities, such as Dayton Ohio, have a large untapped resource in the form of vacant lots that can be transformed into novel ecosystems (Hobbs et al. 2006) benefiting organisms cities once pushed out. While past studies in the city of Chicago showed a positive correlation between pollinators and human density (Lowenstein et al. 2014) our research showed how in the city of Dayton the care taken towards these green spaces regardless of neighborhood have a large effect on pollinator communities. From the data collected we saw there to be a correlation between the various urban landscapes and the pollinator communities. An increase in flowers at the site was related to increase of pollinator visits (Figure 3). This is seen from how the urban garden and vacant lot with overgrowth had larger pollinator communities observed then the lawn. This correlation gives evidence to support our first hypothesis that the ecological makeup of the surrounding environment does have an effect on the frequency of pollinators that visit sites. From this data we cannot make claims as to whether the pollinator species composition differed greatly across the three sites as we only identified to a basic order, however we did discover that although the frequency of pollinators differed across the sites proportionally all sites had a similar hymenoptera to non-hymenoptera ratio (Figure 6).

We also hypothesized that the managed floral urban garden would have a greater pollinator frequency then a site that went unmanaged, the vacant lot. The urban garden did have a higher average pollinator frequency then the vacant lot (Figure 3). It was interesting to discover that the composition of pollinators, hymenoptera vs non-hymenoptera, from the two sites were very similar, on average in observation 31.84% of pollinators where hymenoptera at the urban garden and 34.82% of the vacant lot's pollinators were hymenoptera (Figure 6). An interesting observation was made about the variety of insects at the sites during this early fall experiment. In addition to pollinators, the urban garden had a large number of insects that were not spotted within the vacant lot or lawn such as grasshoppers and praying mantis. This could be explained by the fact that the urban garden site had a wide arrange of plants from native clovers to blooming broccoli, zucchini, okra, and peppers that were not present at other sites.

From this study we saw that landscaping in urban cities plays a large role within pollinator communities. Managed sites that have a variety of flowers have a correlation with high pollinator frequency then sites that have unmanaged growth. The city of

Dayton should focus upon their green spaces and transform them into areas that benefit both humans and the insect community.

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## Figures

Figure 1

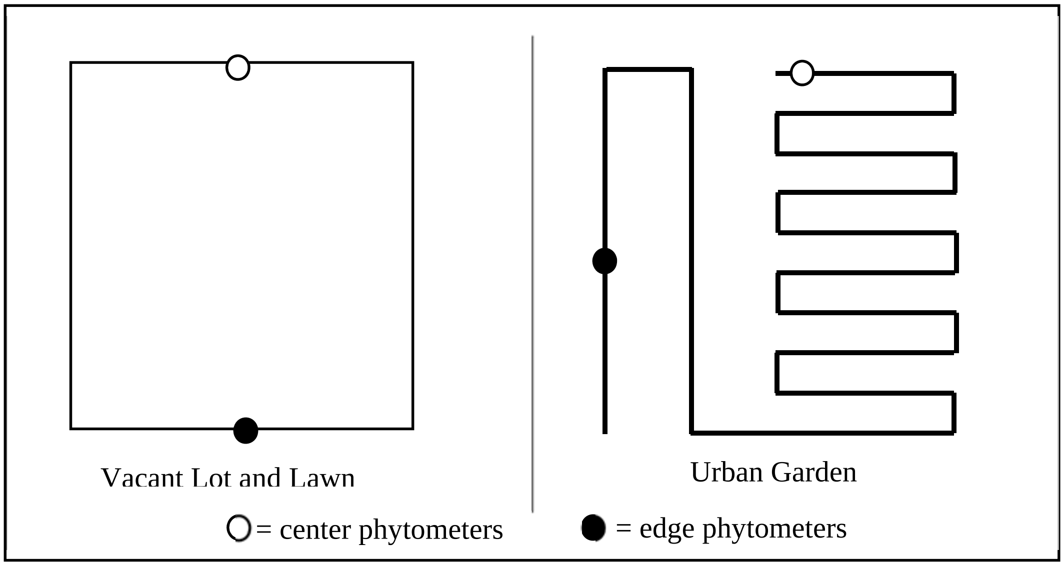


**Figure 1.** Two different walking paths were determined by the size and terrain of the site. The circles indicate where the phytometers where located the white circle shows the ‘near’ phytometer while the filled black circle symbolizes the ‘far’ photometer.

Figure 2

**Figure 2** Set up of phytometer set at the lawn site. This set up was used for each ‘near’ and ‘far’ phytometer set throughout each of the three sites, lawn, vacant lot, and urban garden.

Figure 3

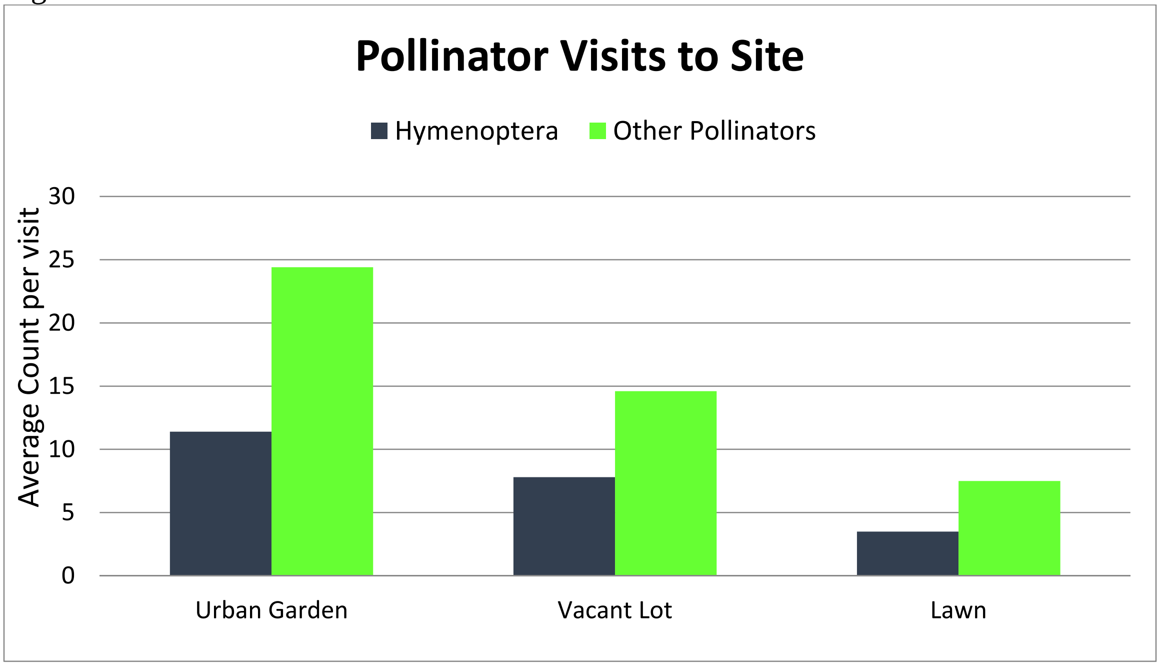


**Figure 3** Analysis of average visits by pollinators to site during observation periods. The Urban Garden had 11.4 hymenoptera and 24.4 other pollinator counts. The overgrown vacant lot site had an average of 7.8 hymenoptera visits and 14.6 visits from other pollinators. The manicured lawn had an average of 3.5 hymenoptera and 7.5 other pollinators.

Figure 4

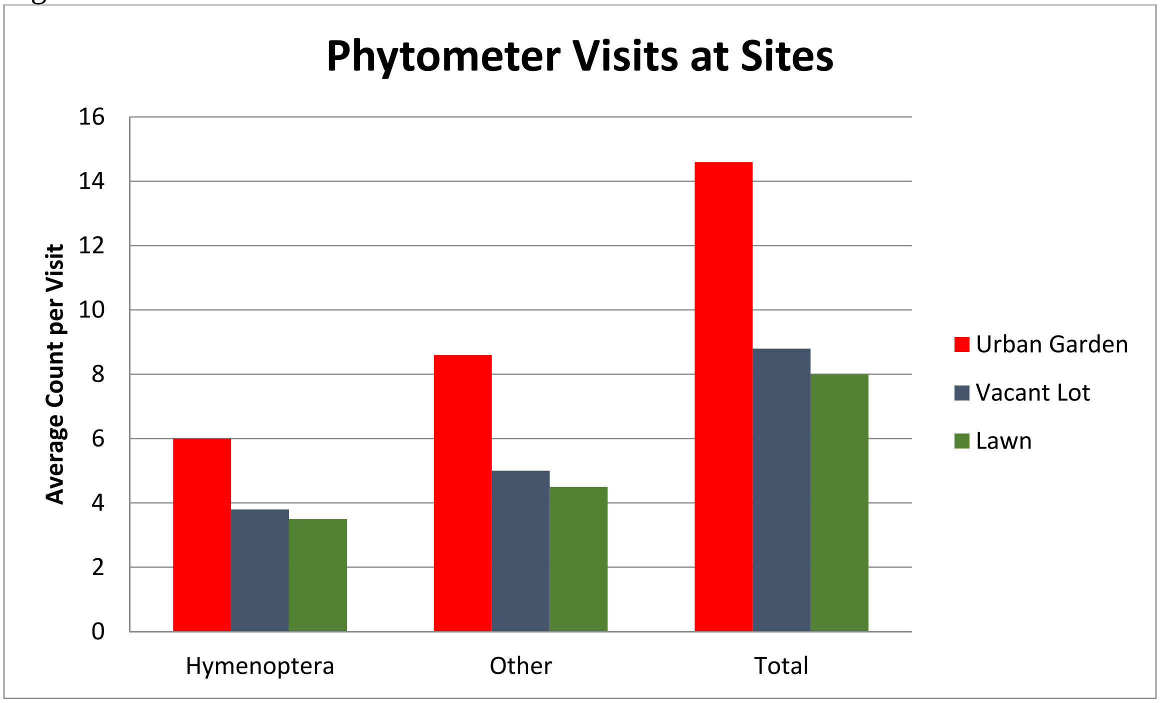


**Figure 4** Analysis of average pollinator visits to phytometers during 10 minute observation. On average the urban garden had the highest frequency of visiting pollinators, 14.6, with 6 on average belonging to hymenoptera. The vacant lot had an average of 8.8 pollinators with 3.8 belonging to hymenoptera. The lawn had an average of 8 pollinators per observation with an average of 3.5 belonging to hymenoptera.

Figure 5

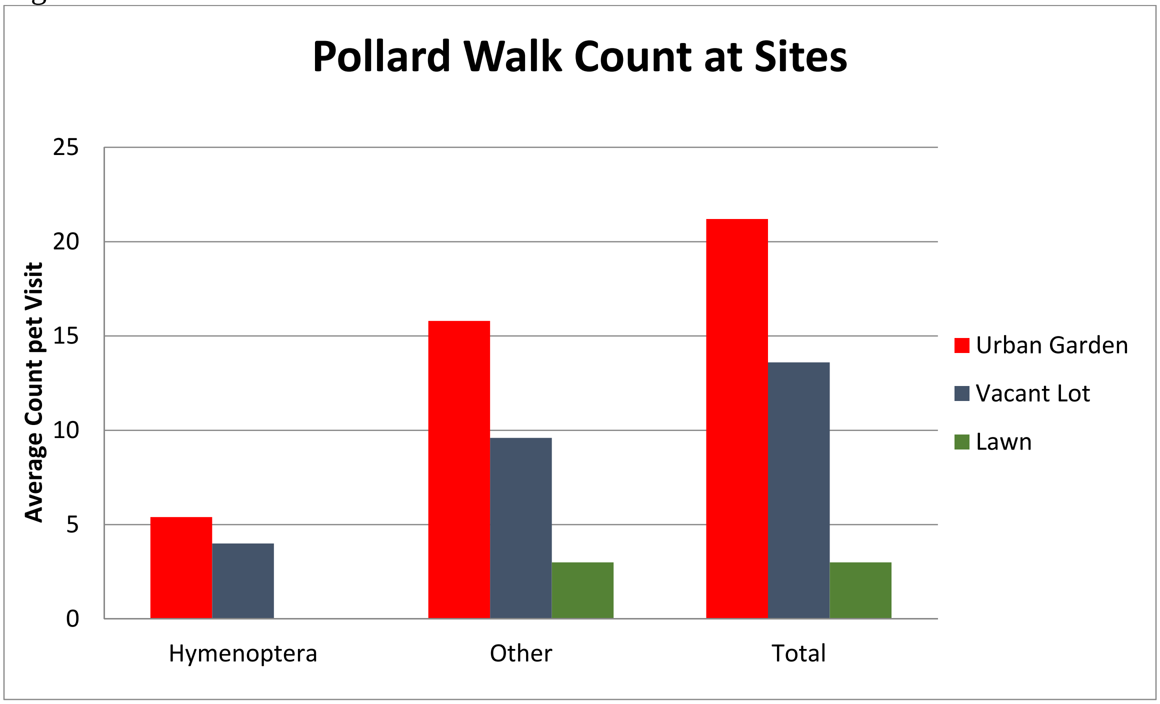


**Figure 5** Analysis of average pollinators observed during 15 minute modified pollard walk of site. On average the urban garden pollinators observed was 21.2, with 5.4 on average belonging to hymenoptera. The vacant lot had an average of 13.6 pollinators seen with 4 belonging to hymenoptera. The lawn had an average of 3 pollinators per observation with no pollinators belonging to hymenoptera.

Figure 6

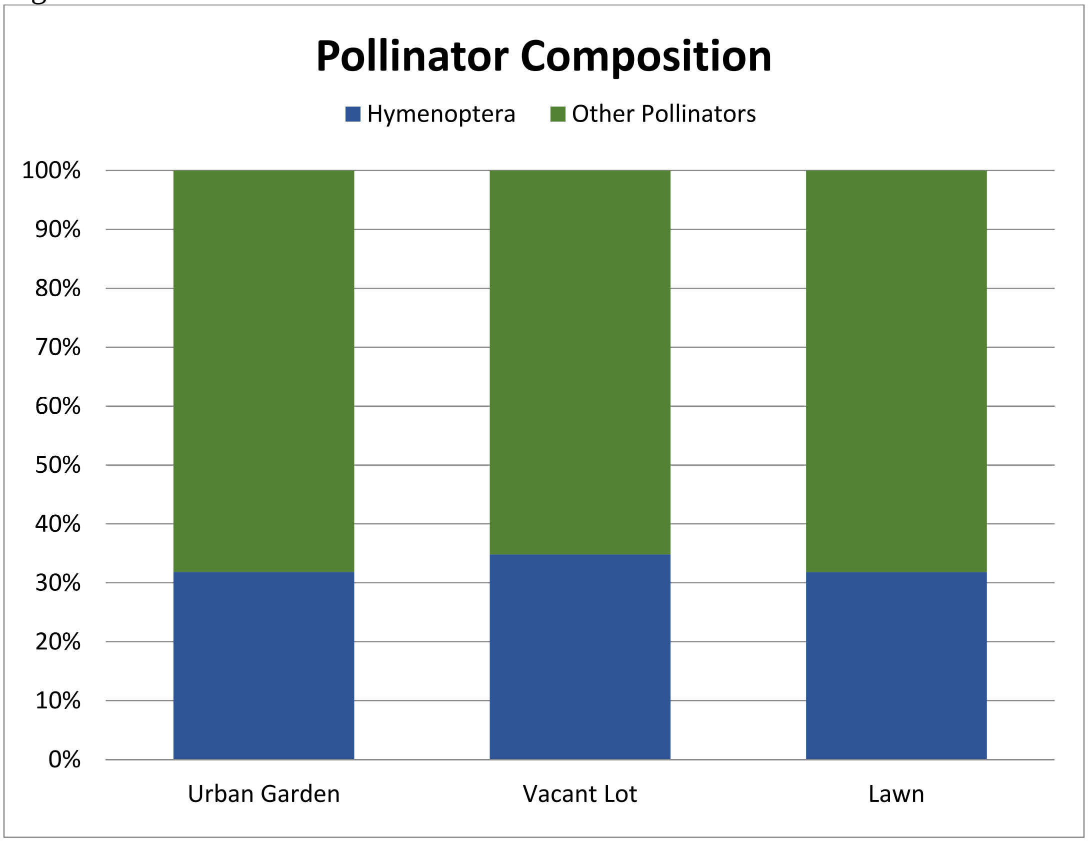


**Figure 6** Composition of average pollinator visits to sites during observations. The urban garden’s hymenoptera composition was 31.84%. The vacant lot’s site hymenoptera composition was 34.82% of total pollinators. The lawn’s hymenoptera composition was 31.82% of total visiting pollinators.

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